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Seasonal Occurrence and Spatial Distribution of Some Anthicid Species (Coleoptera, Anthicidae) in a Rural Area in Kakuma, Kanazawa, Temperate Zone of Japan

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Abstract We examined the seasonal occurrence and spatial distribution of anthicids (Coleoptera, Anthicidae), a poorly known taxon in ecology, collected by net sweeping along a line census route across a rural landscape in a temperate zone of Japan. In this survey, four anthicid species were collected, and two dominant species, *Clavicollis* (*Anthicus*) *fugiens* and *Macratria japonica,* were analyzed. Seasonal patterns of *C. fugiens* and *M. japonica* showed that both species occurred only at a certain time of the study year with clear unimodal peaks of abundance, suggesting that these species are univoltine. Analyses of spatial distribution of anthicids clearly indicated that *C. fugiens* was closely associated with the shrub layer in forests. On the other hand, the spatial distribution of *M. japonica* was restricted to grasslands adjacent to forest edges.

Introduction

Recently, biodiversity has become a central theme in ecology (*e.g.,* CHRISTENSER *et al.,* 1996; PENNISI, 2005). A fundamental question in biodiversity research is how ecological patterns are diverse in nature. To evaluate and conserve biodiversity, it is nesessary to accumulate such basic information as spatio-temporal patterns and the feeding habit of each taxon. However, ecologists have frequently used well-known taxa (*e.g.,* butterflies, carabid beetles, ants, wasps, moths and dung beetles) in ecological studies, because these taxa have been well documented taxonomically and biologically and are able to be effectively sampled using established methods. This biased attention to well-known taxa has led to the ignorance of poorly known taxa in ecological studies. Consequently, little is known about the ecological patterns of poorly known taxa, even as to how species are distributed across habitats and season.

The family Anthicidae (Cucujoidea, Coleoptera) are a species-rich taxon that consists of about 3,000 species worldwide, of which 60 species have been recorded in Japan (SAKAI, 1985). Anthicids are known to show a variety of feeding habits such as omnivore, scavenger, fungivore, predator, and pollen and nectar feeder, and have been found in a wide range of habitats from human habitation to natural environments such as forests, grasslands and near water (see BORROR *et al.,* 1981; SAKAI, 1985; LAWRENCE & BRITTON, 1991; YOUNG, 1991 a, YOUNG, 1991 b; WERNER & CHANDLER, 1995; POLLOCK & IVIE, 1996). Some anthicids play an important role as predators or fungivores in natural communities and have been studied ecologically or entomologically for their value in the biological control of major pests (*e.g.,* BUTLER, 1966; ORPHANIDES *et al.,* 1971; MCCUTCHEON & DURANT, 1999) or mildew (*e.g.,* VILJOEN *et al.,* 1996). As a whole, however, little is known about the ecology of anthicids (WERNER & CHANDLER, 1995; POLLOCK & IVIE, 1996). In particular, few qualitative data are available about the spatial and temporal patterns of these beetles in natural habitats (WERNER & CHANDLER, 1995; WOLDA & CHANDLER, 1996).

As a part of a faunal survey of coleopteran insects in a satoyama landscape, we studied seasonal patterns and spatial distributions of anthicid beetles across different types of vegetation. We conducted net sweeping along a census route across a satoyama landscape in Kanazawa, a temperate zone of Japan. The satoyama is a traditional agricultural landscape in Japan and has been maintained by intermediate disturbance due to human activities such as exploitation of plant resources. The satoyama landscape is characterized by a mosaic of various environments such as woodlands, grasslands, farms and others (TAKEUCHI, 2001; KATO, 2001; WASHITANI, 2001), providing a situation to examine the spatial distribution of various insects across different environments. Net sweeping was selected as an unbiased way to randomly collect coleopteran insects from certain environments. In addition, net sweeping is an effective method to collect anthicids (WERNER & CHANDLER, 1995) as in addition to light traps (*e.g.,* WERNER & CHANDLER, 1995) and cantharidin traps (*e.g.,* CHANDLER, 1976; YOUNG, 1984). During the faunal survey, some anthicid species were collected. In this paper, ecological aspects of anthicid species are reported with special reference to spatial distribution and seasonal occurrence.

Methods

1. *Study site*

The study site was situated in a satoyama landscape on a hilly area (50–160 m a.s.l.) around the Kakuma campus of Kanazawa University in Kanazawa, Ishikawa, Japan (36°32′N, 136°42′E) (Fig. 1). Secondary forests have been established on the slope and the top of the hilly area, and consist mainly of deciduous oak trees such as *Quercus variabilis* BLUME and *Q. serrata* THUNBERG ex MURRAY (Fagaceae) and partly of Japanese cedar, *Cryptomeria japonica* LINNAEUS (Taxodiaceae), and pine trees, *Pinus densiflora* SIEBOLD et ZUCCARINI (Pinaceae). Grasslands with occasional stands of alder trees, *Alnus japonica* THUNBERG (Betulaceae), have been grown at the bottom of the hilly area and are dominated by Poaceae spp., *Persicaria thunbergii* SIEBOLD et ZUCCARINI (Polygonaceae) and *Artemisia* sp. (Balsaminaceae).

A census route was established in the site so as to cover 5 m on both sides of the route and ca. 240 m in length from the bottom to the top of the hilly area. The route was divided into 12 sections ranging from 16 to 21 m in length (Table 1). Sections 1 to 6 were grasslands and sections 7 to 12 were secondary forests. Of these six sections of grasslands, sections 1, 2 and 6 were adjacent to the edges of secondary forests. Sections 4, 5 and 6 were partly covered with marsh area. Of the six forest sections, section 12 included some small gaps due to the death of single pine trees. In each section, we recorded the dominant plant species at each vegetation layer (herb, shrub and tree layers) and counted all woody plants. The number of woody plant individuals per area and the dominant plant species are listed in Table 1.

2. *Sampling method*

Coleopteran insects were sampled in each section by net sweeping along the route in the order from sections 1 to 12 (Fig. 1). The net consisted of a 50 cm diameter hoop with a nylon mesh bag and was fitted to a 1.5 m stick that could be lengthened to 5.4 m. Samples were taken from three different vegetation layers (herb: 0–0.5 m, shrub: 0.5–1.5 m, tree: 1.5-7.1 m high) on the right and left sides of the route in each section. For the herb layer, clumps of Japanese pampas grass, *Miscanthus* sp. (Poaceae), were not swept. The shrub layer included bamboo grass, *Sasa palmata* (BEAN) NAKAI (Poaceae), and the foliage of shrubs, low trees and vines twining around some trees and shrubs. In sections 3 to 5, however, clumps of Japanese pampas grass dominated the shrub layer. The tree layer consisted of the foliage of trees and vines. The total number of sweeps in a census differed among sections and vegetation layers according to plant biomass (Table 1). The survey was conducted from 21 April to 20 October in 1997 at ca. 10-day intervals, resulting in 17 sampling events in total. Each sampling was started between 9 and 10 AM and finished between 2 and 3 PM. All anthicids in the samples were

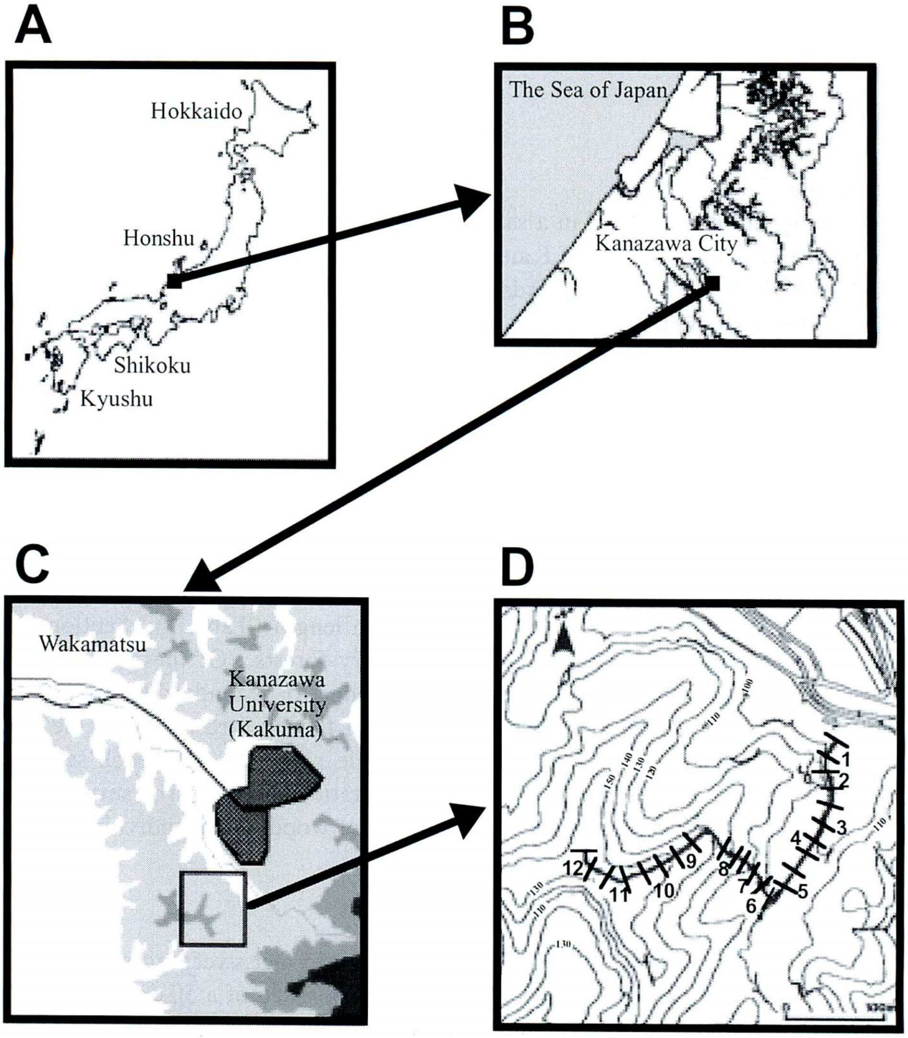

Fig. 1. Map showing the location of Kanazawa City (□ in A and B), Kakuma Campus of Kanazawa University (■ in B and C), and the study site (□ in C).

identified as to species and counted. Anthicid specimens were deposited in Kanazawa University and Kyushu University. In our study, we regard the Macratrinae as a member of Anthicidae according to SAKAI (1985).

3. *Data analysis*

We used only species represented by at least eight individuals. For each species, we standardized the number of individuals collected in each section with the number of

Table 1. Features of sampling sections along the study route in Kakuma, Kanazawa.

Section No.	Length (m)	Number of sweeping	Woody plant density $(/\mathrm{m}^2)$	Vegetation	Dominant plant species in each of three vegetation layers (H: herb, S: shrub, T: tree)	Position on the hill
1	20	87	0.05	Grasslands	H (Poaceae spp., *Persicaria thunbergii, Artemisia* sp.)	Bottom
					S (*Sasa palmata, Pueraria lobata*)	
					T (No dominant species)	
2	18	87	0.06	Grasslands	H (Poaceae spp., *P. thunbergii, A.* sp.)	Bottom
					S (*S. palmata*)	
					T (No dominant species)	
3	20	60	0.04	Grasslands	H (Poaceae spp., *P. thunbergii, A.* sp.)	Bottom
					S (*Miscanthus* sp.)	
					T (*Weigela hortensis, P. lobata*)	
4	17.5	57	0.10	Grasslands	H (Poaceae sp., *P. thunbergii*)	Bottom
					S (*M.* sp.)	
					T (*Alnus japonica*)	
5	19.5	71	0.10	Grasslands	H (Poaceae spp., *P. thunbergii, A.* sp.)	Bottom
					S (*M.* sp.)	
					T (*A. japonica*)	
6	17.5	70	0.11	Grasslands	H (*P. thunbergii*)	Bottom
					S (*S. palmata*)	
					T (*A. japonica*)	
7	16	90	0.42	Forests	S (*Eurya japonica*)	Slope
					T (*Quercus variabilis*)	
8	17.5	100	0.71	Forests	S (No dominant species)	Slope
					T (No dominant species)	
9	21	95	0.95	Forests	S (*S. palmata, E. japonica*)	Top
					T (*Quercus serrata, Pinus densiflora, Cryptomeria japonica*)	
10	21	60	0.63	Forests	S (*E. japonica, Callicarpa japonica*)	Top
					T (*C. japonica*)	
11	20	80	0.48	Forests	S (*S. palmata*)	Top
					T (*Q. serrata, Styrax japonica*)	
12	20	80	0.56	Forests	S (*P. lobata* and others)	Top
					T (*P. densiflora, P. lobata* and others)	

sweeps. We examined whether the number of woody plant individuals per area and anthicid specimens collected differed between sections in grasslands and in forests by the U-test (U). The relationship between the numbers of woody plant individuals and anthicid beetles in each section was tested using Spearman's rank correlation (r_s).

We also applied the indicator method proposed by DUFRÊNE and LEGENDRE (1997) to examine the spatial distribution of each anthicid species across sections. This method combines the relative abundance of a species with the relative frequency of occurrence of the species in each particular habitat type to obtain the indicator value for the habitat type (grasslands and forests in our study). The species indicator value (IndVal) is the maximum indicator value over all habitat types. IndVal is maximum when all species individuals are found in a single habitat type and when a species occurs at all sites of a habitat type. Statistical significance of IndVal was evaluated with the Monte Carlo test (MCCUNE & MEFFORD, 1997).

For each anthicid species, we examined whether the number of individuals collected differed among vegetation layers using Wilcoxon's signed-ranks test (T) or Friedman's test (χ^2).

Results and Discussion

1. *Anthicid species collected from foliage*

In total, 4,590 coleopteran individuals belonging to 45 families and 348 species were collected in this survey. Of these beetles, anthicids were represented by 71 individuals (1.5% of the total number of individuals) distributed to three genera and four species (1.1% of the total number of species). These four species were *Clavicollis* (*Anthicus*) *fugiens* (MARSEUL, 1876) (51 individuals), *Macratria japonica* HAROLD, 1876 (16 individuals), *Anthicomorphus cruralis* LEWIS, 1895 (three individuals) and *Macratria fluviatilis* LEWIS, 1895 (one individual). Although we excluded *A. cruralis* and *M. fluviatilis* from the following analyses of spatio-temporal patterns, we present records of these two species from Kakuma, Kanazawa, Japan as follows.

Anthicomorphus cruralis. 1 ex., Secondary forests (Section 15), 18–V–1997, K. TAKADA leg.; 1 ex., Secondary forests (Section 15), 7–VI–1997, K. TAKADA leg.; 1 ex., Secondary forests (Section 15), 16–VI–1997, K. TAKADA leg.

Macratria fluviatilis. 1 ex., Grasslands (Section 3), 15–VII–1997, K. TAKADA leg.

2. *Seasonal occurrence*

Seasonal patterns in the numbers of *Clavicollis fugiens* and *Macratria japonica* are shown in Fig. 2. *Clavicollis fugiens* was collected from the end of April to mid-June, whereas *M. japonica* was collected from mid-May to the beginning of August. In both species, adults occur only at a certain time of year with a clear peak of abundance, suggesting that both species are univoltine. Such seasonal patterns are the commonest phenomena in the temperate zone (WOLDA, 1988).

In addition to these study data, we compiled two observational records from Ishikawa Prefecture (TAKABA *et al.,* 1998) and Odamiyama district in Ehime Prefecture (SAKAI, 2000), and compared the patterns of seasonal occurrence of *Clavicollis fugiens* and *Macratria japonica,* and six other species, represented by at least eight observations (Table 2). These observational records were obtained by various sampling methods from a number of places in each region. Thus, we were only able to compare the rough features of their patterns of seasonal occurrence. In these studies, most species were collected from spring to summer and their seasonal lengths of occurrence

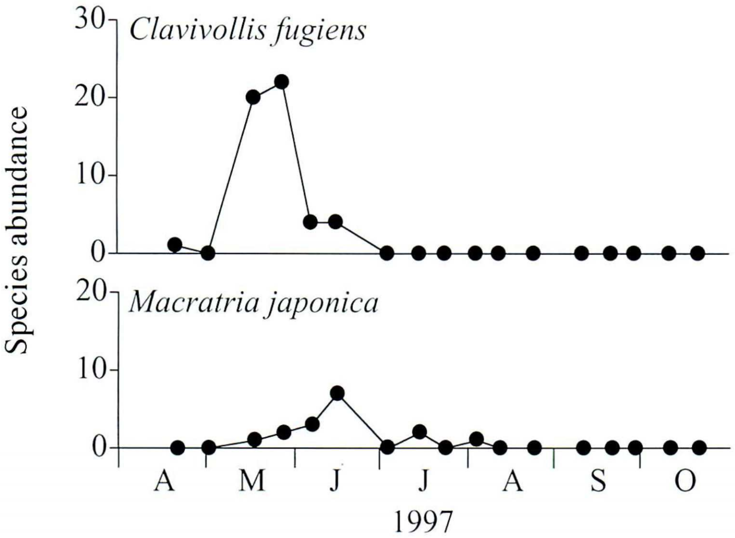

Fig. 2. Seasonal change in the total number of anthicid individuals collected by net sweeping in Kakuma, Kanazawa.

Table 2. Seasonal occurrence of anthicid species collected in our study (□), and reported from Ishikawa Prefecture (■) in TAKABA *et al.* (1998) and from Odamiyama district in Ehime Prefecture (▲) in SAKAI (2000).

Species	Month								
	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.
Neostereopalpus nipponicus (LEWIS)					■	■			
Macratria fluviatilis LEWIS				▲	▲	▲			
serialis LEWIS				▲	▲	▲			
japonica HAROLD			□	□	□	□			
Derarimus clavipes (CHAMPION)	▲		■▲	■▲	■▲	■	■▲	▲	▲
Anthicomorphus niponicus LEWIS			▲	▲	▲	▲			
Clavicollis fugiens (MARSEUL)		□	□■▲	□■▲	■▲	▲	▲		
Sapintus cohaeres (LEWIS)				▲	▲	▲			

ranged from two to five months. This suggested highly seasonal occurrences of these anthicid species in the temperate zone of Japan. On the other hand, *Derarimus clavipes* (CHAMPION, 1890), which lives in leaf litter (SAKAI, 2000), were collected from March to November, except for April and August, in Odamiyama. The occurrence of this species may be seasonally less restricted even under the seasonal environment in temperate Japan.

3. *Spatial distribution*

The number of woody plant individuals was larger in forest sections than in grassland sections (0.08±0.03 in grassland sections, and 0.62±0.19 in forest sections, U test, $U=0.00$; $P<0.01$). The number of individuals of *Clavicollis fugiens* was significantly larger in the forest sections than in grassland sections (0.28±0.68 in grassland sections, and 10.23±6.68 in forest sections, U test, $U=0.00$; $P<0.01$). On the other hand, *Macratria japonica* showed no difference between vegetations, although all individuals of this species were collected in grasslands (3.07±5.98 in grassland sections, and 0 in forest sections, U test, $U=12.00$; $P=0.14$) (Fig. 3). The positive correlation between the numbers of specimens collected and woody plant individuals across sections was significant in *C. fugiens,* whereas the negative correlation was marginally significant in *M. japonica* (Table 3). Large IndVal for *C. fugiens* indicates that this species is widely distributed across sections in a particular vegetation type (Table 3, Fig. 3). IndVal for *M. japonica* was small due to their distribution restricted to only two sections in grasslands (Table 3, Fig. 3). While the number of individuals of *C. fugiens* was significantly larger at the shrub layer than at the tree layer in forest sections (Wilcoxon's signed-ranks test, $T=0.00$, $P<0.05$), *M. japonica* showed no difference among vegetation layers in grassland possibly because of the low frequency of occurrence across grassland sections (Friedman's test, $\chi^2=0.286$, $P=$n.s.).

These results for the spatial distribution of anthicids clearly indicate that *Clavicollis fugiens* is closely associated with the shrub layer in forests. On the other hand, *Macratria japonica* showed a pattern of distribution restricted to sections 1 and 2 in grasslands, both of which were adjacent to forest edges. SAKAI (2000) has reported that *Macratria fluviatilis* and *Macratria serialis* LEWIS, 1876 were collected at forest edges. This suggested that some *Macratria* species are closely associated with forest edges. Most anthicid species have been classified into one of three ecological types, riparian, grassland and forest types (WERNER & CHANDLER, 1995; SAKAI, 2000). Of the anthicid species studied, *C. fugiens* obviously belongs to the forest type; however, it seems unsuitable to assign an ecological type to *M. japonica* based on these three types, because this species is likely to be specific to the environmental boundary between forest and grassland. Rather, we suggest that the forest edge should be added to the

Table 3. Rank correlation coefficient (r_s) between the number of anthicid specimens and woody plant individuals and the species indicator value for each anthicid species.

Species	Correlation coefficient (r_s)	IndVal (%)	Total number of individuals per 100 sweeps/sites recorded	
			Grasslands	Forests
Clavicollis fugiens	0.84***	97.3**	2/1	61/6
Macratria japonica	−0.51*	33.3	18/2	0/0

*$0.05<P<0.1$; **$P<0.05$; ***$P<0.01$.

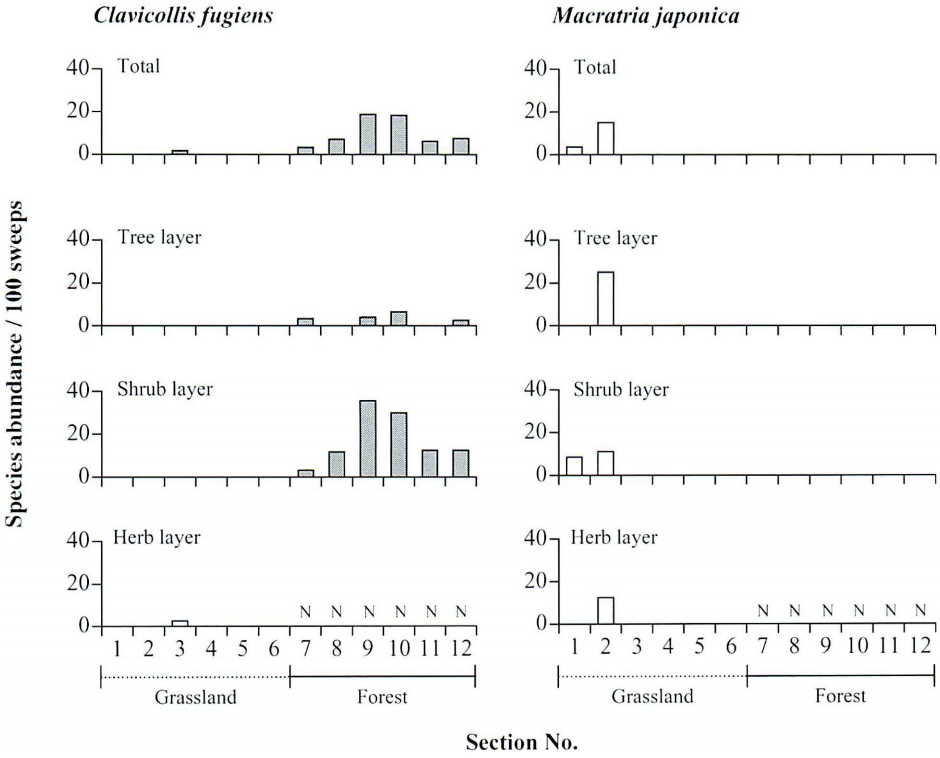

Fig. 3. Distribution of the number of anthicid individuals collected per sweep of three vegetation layers across the 12 sampling sections. Lines below the section numbers indicate the vegetation (solid line: forest, dotted line: grassland). N: no sweeping (no foliage).

classification system as a new ecological type of anthicid species based largely on habitat preference in order to make the system more useful for further ecological studies on anthicids.

Acknowledgement

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要　　約

高田兼太・田辺慎一・高羽正治・中村浩二：日本温帯域の里山におけるアリモドキ科（Anthi-

cidae）に属する数種の季節変動と空間分布パターン．

1. 1997年4月から10月にかけて，金沢市角間丘陵にある金沢大学角間キャンパス周辺の二次林と草地で実施されたスウィーピング法によるラインセンサス調査で得られたアリモドキ科，とくにアカホソアリモドキ *Clavicollis fugiens*（51個体）とキアシクビボソムシ *Macratria japonica*（16個体）の季節変動パターンと空間分布パターンを調べた．

2. ラインセンサス調査で得られたアリモドキ科のうち，アカホソアリモドキは4月下旬から6月中旬に，キアシクビボソムシは5月中旬から8月上旬にかけて出現した．両種ともに季節消長のピークは1回であり，出現時期も限られていたことから，これらの種は年1化であることが示唆された．また，本研究で得られたデータに加え，石川県および愛媛県小田深山で非定量的採集により得られたデータを用いて，アリモドキ科8種の出現時期と出現期間の長さを比較した．その結果，7種は春から夏にかけて出現し，それらの出現期間は2カ月から5カ月であり，これらの種は日本の温帯域において，高い季節性をもつことが示唆された．

3. ラインセンサス調査で得られたアリモドキ科2種の空間分布パターンを解析した結果，アカホソアリモドキはおもに二次林内の低木層に広く分布し，キアシクビボソムシは林縁部付近の草地にのみ分布することがわかった．本科に属するほとんどの種は，生息地選好性から，水辺性の種，草地性の種および森林性の種に分けられるが，前種は森林性の種であると考えられた．しかしながら，後種は3つのタイプの種とも異なる林縁性の種であることが示唆された．

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New Localities of the Japanese *Leptepania* Species (Coleoptera, Cerambycidae)

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Two allopatric species of the molorchine genus *Leptepania* have so far been known from the Japanese Islands, *viz., L. japonica* (HAYASHI) from the main islands south of the Kantô District of Honshu and *L. ryukyuana* HAYASHI from the Ryukyu Islands south of Yakushima. Though having been regarded as two independent species, the western population of *L. japonica* shows a morphological cline towards the northern population of *L. ryukyuana*. The Shikoku population of *L. japonica* has oblong smooth areas at the centre of pronotum and weakly raised apical halves of the elytra which have only a few punctures like those of *L. ryukyuana*, and is barely discriminated in external morphology from the Ryukyu species by the longer and subparallel-sided elytra. Recently, I was able to examine *Leptepania* specimens from two new localities in